

have not been so striking. We believe it especially useful in cases, as above detailed, where violent maniacal attacks are suffered from. We see no reason why it ought not to prove of service in some other serious diseases, such as hydrophobia, tetanus, and, as my colleague, Dr. Eldridge, suggested to me, in delirium tremens. The drugs, it is true, are powerful nervous sedatives alone, but it appears some additional strength is developed by their union, as ten grains of camphor or of chloral hydrate, separately, would have, we all know, about as much effect on a maniac as so much water.

ARTICLE VIII.

ON FRACTURES OF THE CRANIAL BONES. By JOHN A. LIDELL, A.M., M.D., of New York, late Surgeon to Bellevue Hospital, Inspector of the Medical and Hospital Department of the Army of the Potomac, etc. etc.

FRACTURES of the skull are among the most difficult and important objects of surgery. They are attended with very great fatality. Of 117 cases treated at the New York Hospital 96 died, and only 21 recovered (*Lente*). Of 230 cases of gunshot fracture of the cranium, which occurred in the British Army in the Crimea from April 1, 1855, to the end of the war, 170, or 73.9 per centum, died (*Med. and Surg. Hist. of British Army in Crimea, etc.*, vol. ii. p. 286). Of 4022 cases of gunshot fracture of the skull, which happened during our war of the rebellion, 2559, or 63.6 per centum, proved fatal (*Med. and Surg. Hist. of the War of the Rebellion, Surgical Vol.*, Part 1st, p. 307). And of 105 cases of cranial fracture caused by falls and blows on the head, and by miscellaneous injuries other than gunshot and bayonet wounds, which also happened during our war of the rebellion, 57, or 54.28 per centum, likewise proved fatal (*Ibid.* p. 68). Moreover, fractures of the cranial bones constitute a theme of great interest to every practical surgeon, because their treatment is less clearly settled and defined than that of most other forms of injury, although they have been attentively studied by the most gifted surgeons in every age from the time of Hippocrates until the present day. Indeed, directly opposite views are entertained and expressed by prominent surgeons of our own time, concerning the utility of the operation of trephining, and of the various procedures for elevating depressed fragments in cases of cranial fracture; likewise concerning the employment of bloodletting, mercury, antimony, and other depressing remedies in treating the inflammatory complications and sequelæ of such fractures. Whoever, then, shall relate his personal observations and researches on these important subjects in a clear, impartial, and concise manner, may possibly instruct as well as amuse the thoughtful reader.

Fractures of the skull, like fractures of most other bones, may be *simple*, *compound*, *comminuted*, and *complicated*. They are not unfrequently spoken of as *without displacement*, *with displacement*, and with *impaction* of the fragments; also as *linear* or *fissured*, *stellate*, *punctured*, *depressed*, *camerate*, *gunshot*, etc. The following pages of this article will be made up, in great part, of cases which have passed under my own personal observation.

1. *Linear or Fissured Fractures* when restricted to the vault of the cranium are, very frequently, not discerned during life, since this lesion is not characterized by any specific symptoms. If, however, an external wound be present, the line of fracture can generally be detected without much difficulty on making suitable exploration of the wound; but, while doing this, it should be remembered that abnormal position of a cranial suture may deceive the surgeon, and lead him to mistake such misplaced suture for fissured fracture. Moreover, fissured fractures of the skull are dangerous lesions. Even when restricted to the cranial vault they not unfrequently destroy life by lacerating the meningeal arteries which run along the grooves on the internal table, thus causing the extravasation of blood in great quantity between the dura mater and the skull, and fatal compression of the brain. The following example affords a good illustration of this important point:—

CASE I. Linear Fracture of Skull caused by a Blow on Left Temple; Death in eighteen hours from Cerebral Compression; Autopsy; Middle Meningeal Artery found Lacerated, etc.—An unknown man, apparently of middle age, assaulted a policeman with a knife, on the night of September 9th. The officer attempted to disarm him with his club, but, failing in this, struck him smartly on the left temple also with his club. The man instantly fell senseless. He was picked up and carried to the station-house, where he lay in a state of complete insensibility, having coma and stertor, for eighteen hours, when he died. He was treated by a police surgeon. The writer examined the dead body for the coroner.

Autopsy, eighteen hours after death. The marks of recent contusion were found on the left temporal region, *i. e.*, the skin was discoloured blue-black, and there was a moderate amount of swelling having a soft feel, but the integuments were not broken. Beneath the scalp at this place some extravasated blood was found. The tissue of the temporal muscle at this spot was pulpified and infiltrated with blood. In the same region a linear fracture of the skull, without displacement, was also found; it extended downwards into the base of the cranium. Likewise, a large coagulum was met with between the bone and the dura mater, at the place of injury in the left temporal region, which flattened the convolutions, and distorted the brain-substance. It was equal to about three ounces and a half in volume, and it had destroyed life by compressing the brain. The blood which formed it had escaped from a lacerated branch of the middle meningeal artery of that side. This vessel had been torn across at the line of fracture by the springing of the broken bone which resulted from the blow. The sinuses and the veins of the brain were all full of blood. Each lateral ventricle contained a small quantity of bloody serum.

Comments.—This fissured fracture involved the left parietal and temporal bones, and extended from above downwards into the basis cranii. The blow which caused it produced also violent concussion of the brain, insomuch that the man at once fell unconscious to the ground. Soon, however, the insensibility of cerebral concussion was succeeded by the insensibility and paralysis of cerebral compression, blood was rapidly effused from the disrupted middle meningeal artery, between the dura mater and the fissured bones, so that in a short time the brain-substance was subjected to dangerous compression in consequence of the ever-increasing volume of sanguineous extravasation. In this case, then, no interval of restored consciousness appeared between the period of insensibility due to cerebral concussion and the final period of insensibility due to cerebral compression. In many cases, however, belonging to this category the symptoms of cerebral compression do not appear until the lapse of considerable time after the fracture has occurred; and in such cases the patient recovers consciousness as the symptoms of cerebral concussion depart, but loses it again and becomes hemiplegic and comatose as the symptoms of cerebral compression supervene. Moreover, in some very rare instances, a period of even two or three days, wherein the patient remains fully sensible, is interposed between the fracturing of the skull on the one hand and the occurrence of cerebral compression from intracranial hemorrhage on the other. That happened in the following remarkable example:—

CASE II. Injury of Head from being knocked down; no Loss of Consciousness; Found Dead in Bed on third Morning afterwards; Autopsy; Linear Fracture of Skull; Large Coagulum between Dura Mater and Skull, etc.—Peter E., a lad of 15, on November 4th was assaulted by a ruffian, who knocked him down and then ran away. He got up without assistance, and walked to a neighbouring drug store, where he appeared somewhat confused from fright as well as from “stunning,” but did not exhibit the symptoms of much “shock.” He walked home without assistance. The next day he remained at home. On the following morning he went to his work, which consisted of covering trunks, although he said he did not feel entirely well. Nevertheless, he did a “good day’s work.” When he came home he complained of having a severe pain in his left ear, but got some relief from it in the course of the evening. On the next morning (November 7th), he was found dead in his bed in the posture of quiet slumber. He did not make any complaint whatever after going to bed. His mother slept in the adjoining room with the communicating door open, and she was not disturbed. Before his death it was not thought that he was seriously injured. There was no physician in attendance.

Autopsy, made by the writer, November 8th. There was an ecchymosis on his left temple; beneath this bruised spot some extravasated blood under the scalp. A fissured fracture of the skull was found in the same region; the line of this fracture passed downward and forward to the base of the cranium, in front of the meatus auditorius internus. At the place of fracture the skull was very thin. Both tables were broken, but there was no perceptible displacement. On removing the calvaria we found, at the place of fracture, between two and three ounces of coagulated blood,

lying between the dura mater and the bone, and having a perfectly fresh appearance. The left hemisphere of the cerebrum was obviously compressed by this clot, for the convolutions were flattened and the surface depressed, but in every other respect the brain and its membranes appeared to be healthy. The hemorrhage had evidently occurred from the middle meningeal artery, but we failed to ascertain by even careful search what portion of that vessel had been lacerated. It is, therefore, probable that some small branch was in fault.

Comments.—This case gives rise to some very interesting queries. Was this lad's death caused by the fissured fracture of the skull? There does not appear to be any good reason for doubting it. But why did so much time elapse between the fracturing of the skull and the occurrence of cerebral compression in consequence of meningeal hemorrhage? Why did he complain so little during this interval? Why was the appearance of dangerous symptoms so long delayed? When he arose from the ground where he had fallen when struck, he exhibited slight symptoms of cerebral concussion. On the second day afterwards, however, he felt so well that he returned to his ordinary avocations, and did a good day's work. No symptoms whatever of cerebral compression had yet appeared. But on the following morning he was found lying dead in bed, and the post-mortem examination revealed lesions that had not even been suspected before it was made. It is certain that he could not have worked all day, as he did, with a mass of clotted blood, exceeding a two-ounce vial in size, pressing upon the left cerebrum. A much smaller amount of compression would inevitably have produced hemiplegia of his right side. Two hypotheses may be framed with a view to account for the strange phenomena of this case. One of them is, that the hemorrhage occurred very slowly from some small branch of the middle meningeal artery which had been lacerated by the fracture, and that the pressure of the effused blood upon the brain was increased so slowly that paralysis and other signs of arrested innervation were not developed until November 6th, after he had gone to bed. The other hypothesis is, that the fatal effusion of blood occurred suddenly on the night of his death from perforation of the middle meningeal artery by ulceration in some spot where its coats had been partly torn through by the fracture. But this hypothesis lacks the support which would have been furnished by the presence of inflammatory products in the vicinity of the fracture; for, on making careful search, I did not discover any evidence of inflammatory action except a slight loosening of the pericranium along the line of fracture. Still, I am inclined to think that this hypothesis is correct, and the slough was limited to some part of the arterial coats which had been much injured, perhaps almost torn through, by the sharp edges of the broken bone when the fracture occurred.

When blood is extravasated within the cranium in connection with linear fracture of the skull, the seat of effusion is generally found to be on the dura mater, between the bone and that membrane, as it was in the

cases related above. But sanguineous extravasation in similar cases is not restricted to that locality; for, instead thereof, it may occur in the cavity of the arachnoid, and in the meshes of the pia mater and sulci of the brain beneath the visceral arachnoid membrane, as in the following instance :—

CASE III. Injury of Head caused by Falling Down-stairs; Coma; Death in two hours; Autopsy; Fissured Fracture of Skull; Immense Extravasation of Blood in Arachnoid Cavity and underneath Visceral Arachnoid, etc.—Thomas P., æt. about 60, was found lying on a heap of manure in a stable-alley, asleep and apparently intoxicated, on May 10th. He walked several blocks to the station-house with but little assistance. While descending the stairs to the lock-up he fell, striking on his head, but did not seem to have hurt himself much. He got up and walked to the cells. Two hours afterwards, *i. e.*, at 7 o'clock P. M., he died. He was comatose and had stertorous breathing.

Autopsy, by the writer, seventeen hours after death. Rigor mortis marked. Left eyelids blackened by contusion. On dissecting off the scalp a large bruise was found over the right temporal muscle, which extended some distance posteriorly. The skull was fractured above and behind the right ear. The fracture was a simple fissure, involving both tables, and extending into the base of the cranium, behind the meatus auditorius internus. A large quantity of coagulated blood was found in the cavity of the arachnoid membrane, and in the meshes of the pia mater underneath the visceral arachnoid. This extravasation was spread out over the whole surface of both cerebral hemispheres. The coagulum was thicker on the anterior lobe of the left cerebral hemisphere than elsewhere. The substance of the brain was considerably softened at the base of the middle lobe of the right cerebral hemisphere. The right lateral ventricle contained a small quantity of sero-sanguineous fluid. The dura mater was not injured, and no blood was extravasated between it and the cranium. The left lung exhibited in its inferior lobe numerous brown-coloured spots where blood was effused into the pulmonary tissue (apoplexy), which were due to the cerebral lesion as shown by the experiments and researches of Prof. Brown-Séquard (*Lancet*, Jan. 7, 1871).

The following example presents an instance of linear fracture of the skull and meningeal hemorrhage that was complicated with cerebral contusion and ecchymosis, and was followed by cerebral inflammation and abscess.

CASE IV. Contusion of Head caused by Striking it against the pavement. Cerebral Concussion; Encephalitis; Coma; Death; Autopsy; Fissured Fracture of Skull; Diffused Meningeal Hemorrhage; Cerebral Convolutions Ecchymosed; Cerebral Abscess.—Mr. C., aged about 30, was knocked down, Oct. 3d, by a powerful blow upon his breast, his head striking the sidewalk as he fell. He was picked up in a state of complete insensibility. Thirty-six hours afterwards he recovered consciousness sufficiently to tell where he lived and many of the circumstances concerning his injury. He was taken to his home, where he lingered, with symptoms of irritation and inflammation of the brain, until Oct. 9th, when he died *comatose*.

Autopsy, by the writer, twenty-four hours after death. Beneath the scalp on the right parieto-occipital region a considerable quantity of blood was found diffused in the loose connective tissue underneath the occipito-frontalis. In the same region the skull had sustained a fissured fracture,

without displacement. Beneath the visceral arachnoid membrane, over all the right hemisphere of the cerebrum, blood was found extravasated in the meshes of the pia mater, so as to fill more or less completely the furrows between the convolutions of this part of the brain. Underneath the place of fracture the convolutions themselves presented a bruised or ecchymosed appearance. A black clot of blood, somewhat larger than an almond, and flattened in shape, was found at the base of the middle lobe of the right cerebral hemisphere, and the portion of the visceral arachnoid and pia mater in relation with it were so much disorganized that I could not determine whether this extravasation had occurred beneath the visceral arachnoid in the meshes of the pia mater or in the arachnoid cavity. The cerebral substance alongside this clot was much softened to the depth of nearly an inch, and so much disorganized that its natural structure could not be discerned. It was yellowish in colour and puriform in consistence. Another, but smaller, coagulum was found at the base of the anterior lobe of the cerebrum on the same side. This clot seemed from colour and consistence to have had a more recent origin than the other clot. The cerebral substance surrounding it exhibited *white* softening. The right lateral ventricle contained about two drachms of sero-sanguinous fluid, and the left about half a drachm. No blood was effused between the cranium and dura mater, and that membrane was not lacerated.

The next case is an example of fissured fracture extending across the base of the skull from ear to ear, and attended with copious effusion of blood upon the base of the brain, the medulla oblongata, and the upper end of the spinal cord.

CASE V. Sudden Death from Injury of the Head caused by Powerful Machinery; Autopsy, etc.—On September 19th the writer made a *post-mortem* examination of the body of Charles L. L., who had been killed on the previous day by being caught in one of the side paddle-wheels of a steamboat.

Rigor mortis strong. Left ear torn off close to the head. There was some blood in the right ear and in the nostrils, and bloody fluid was flowing from the mouth. The examination of the skull revealed a fissured fracture without displacement, extending across its base from ear to ear. A considerable quantity of extravasated blood was found about the base of the cerebellum, the medulla oblongata, the upper end of the spinal cord, and along the track of the optic nerves. The ventricles contained a small quantity of bloody serum. Upon the convex surface of the cerebral hemispheres a large quantity of colourless serum was seen beneath the visceral arachnoid membrane, in consequence of which it presented a jelly-like appearance. This effusion was more copious at the vertex than elsewhere. The presence of this transparent serum in large quantity on the convex surface of the brain seems very remarkable, when we reflect that death occurred almost instantaneously.

In each of the foregoing cases the fracture consisted of a single linear fissure or crack of considerable length, and unattended with displacement, which involved both tables of the skull. Instances, however, are by no means rare in which the fracture consists of two or more fissures or cracks, which either meet or cross each other at more or less acute angles of intersection. In the following example the fracture was composed of two

linear fissures, which joined each other in such a way as to form something like the capital letter *T* in italics.

CASE VI. Sergt. A. N. was thrown from his horse, his head striking violently upon the pavement. He was taken to the hospital in an insensible condition, and, in a few hours, became delirious. He remained so until his death, which occurred four days afterwards. There was simply a severe contusion of his forehead, without any external evidence of fracture of his skull. The *autopsy*, however, revealed a three-branched fracture of the frontal bone. One fissure extended from the middle of the upper edge of this bone downward and outward through the right frontal eminence. From the upper third of this fissure another crack extended downwards, at nearly right angles, through the left frontal eminence; and this crack involved the external table only. The inner table was fissured to correspond with the first line of fracture, and there was also a short fissure branching upwards. The inner table was reticulated beneath each frontal eminence, and in the centre of the cracked plate on the left side there was a small nodule of bone, having the size of a grain of wheat. (*Med. and Surg. History of the War of the Rebellion*, Surg. Vol., Part I., p. 43.)

In the next example there was semicircular fissuring of the external table and stellate fissuring, with slight depression of the inner table, from which a long crack, involving both tables, extended directly downwards.

CASE VII. David H., aged 35, was admitted to the hospital Feb. 24, 1866, with all his toes frost bitten. This seemed to constitute all his trouble, with the exception of headache, which was attributed to constipation. During the next three days his toes improved, but the dull, heavy pain in his head continued. On the 28th he was found comatose, and slight paralysis of his right side was observed. In front of the left parietal protuberance, an incised scalp wound, an inch or more in length, was also discovered, but no other lesion of the scalp could be found. On the supposition that there was cranial fracture, a crucial incision was made in the scalp, and the flaps reflected, for the purpose of trephining, but, as no lesion of the skull could be detected, that operation was abandoned, and the incision closed. The coma and hemiplegia were then ascribed to apoplexy. On the following morning he died. At the *autopsy* a semicircular fissure of the external table of the skull was found just in front of the left parietal protuberance, and stellate fissuring, with slight depression of the inner table, including a space one inch in diameter. From this point a fissure, involving both tables, extended to the middle of the left branch of the lambdoidal suture. There were no traces of attempt at repair. Underneath the stellate fracture of the inner table, with slight depression, a small coagulum was found. The scalp wound did not correspond in position externally to the coagulum and the stellate fracture. These lesions, however, were not the cause of death. It was found on the other side of the head, and consisted of compression of the right cerebral hemisphere from meningeal hemorrhage. When the skull-cap was lifted, between two and three ounces of blood escaped from that side, still leaving a coagulum, which covered the whole hemisphere. This hemorrhage must have occurred during the closing hours of life, and to produce it some large artery must have burst. The paralysis of the right side was due to the coagulum and osseous depression which were found on the left cerebral hemisphere. (*Ibid.* p. 49.)

The fissuring of the internal table was much more considerable than the corresponding lesion of the external table in the case just related; and the fragments of the internal table were also slightly depressed. In the following example there was a good deal of depression of the inner table, while there was only a slight fissure of the outer table:—

CASE VIII. Wm. H., aged 43, was admitted to hospital May 14, 1865, with a bruise on the left forehead, received in a street fight a few hours previously. The injury was regarded and treated as a simple contusion of the scalp. On

May 20th the patient suddenly became comatose, and died on the following day. The *autopsy* revealed a slight fissure of the outer and a considerable depression of the inner table. An abscess of considerable size extended some distance beneath the frontal bone. (*Ibid.* p. 49.)

The following case belongs to the same category as the last, although the existence of cranial fracture was recognized during life. In it the outer table of the os frontis was broken without depression, *i. e.*, it was fissured, while the inner table was driven in upon the membranes of the brain:—

CASE IX. James C., aged 24, fell from his horse on July 6, 1863, receiving a wound of the frontal region with fracture, and depression of the inner table of the skull. He entered hospital July 24th in an irritable, morose, and restless condition. Three days subsequently he was slightly delirious, and respiration was difficult. In the afternoon he became completely unconscious, with insensible pupils and stertorous breathing, and death ensued in a few hours. The *autopsy* revealed a depression of the inner table of the frontal bone, and an abscess immediately beneath filled with sanious pus, and surrounded with plastic lymph. Many of the sulci were adherent, and patches of lymph were distributed on the anterior and middle lobes of the cerebrum. (*Ibid.*, p. 42.)

Comments.—Fissured or linear fractures of the cranium are not attended with depression except in those comparatively rare instances, of which we have just presented three examples, wherein the internal table was comminuted and the fragments driven in upon the dura mater; but such cases are not linear fractures in the strict sense of the term, for they are closely related to those comminuted fractures of the inner table of the skull, which are not accompanied by any fracture of the outer table. Such cases, while they seem to be linear fractures, when examined externally, are, in reality, comminuted fractures with depression of the fragments, and are liable to all the risks of suppurative inflammation of the membranes and substance of the brain which pertain to that class of injuries. Such cases, as a rule, cannot be saved without the timely employment of the trephine and the extraction of the offending splinters of bone.

An attentive consideration of the foregoing cases, however, together with many others of the same sort which are on record, clearly shows that linear fracture of the skull, properly so-called, does not often prove fatal, *per se*, but, that when life is endangered or destroyed in connection with this form of injury, it is generally by reason of some lesion of the underlying parts with which the fracture is incidentally complicated or followed, rather than by reason of the fracture itself. For example, in Cases I. and II. the middle meningeal artery having been incidentally lacerated, blood was extravasated in large quantity between the skull and dura mater with fatal effect. In Case III. rupture of some cerebral artery of considerable size incidentally occurred, with effusion of blood therefrom into the arachnoid cavity and into the sub-arachnoid spaces upon the surface of the brain itself, also with speedily fatal effect. In Case IV. the delicate tissue of the convolutions and medullary substance was bruised and ecchymosed by the same stroke that cracked the skull, and this injury of the brain-substance gave rise to cerebral inflammation and cerebral abscess,

with widespread extravasation of blood beneath the visceral arachnoid membrane, which likewise proved fatal after the lapse of some days. The treatment of linear fracture of the skull, therefore, resolves itself mainly into doing what is required by the various pathological conditions with which it may be complicated, for the surgeon can arrest the tendency to death only by their removal. Now, in the several cases just enumerated, the cause of death was compression of the brain, but, at the same time, it is a fact of great practical moment that the seat and nature of the compressing force were not the same in all of them, and that they presented wide differences in these important particulars. Thus in Cases I., II., and III., the compression of the brain was caused by extravasated blood, but in Case IV. by purulent matter. In Cases I. and II. the blood was effused from the middle meningeal artery between the skull and the dura mater, while in Case III. it flowed from some ruptured cerebral artery into the arachnoid cavity and into the spaces beneath the visceral arachnoid membrane on the surface of the cerebral hemispheres. In Case IV. the purulent matter was formed in the bruised part of the brain itself in consequence of traumatic inflammation thereof.

The chief indication for treatment in all these cases obviously was to relieve the brain of compression. But, at the same time, it is easy to perceive that a remedial measure, such as perforating the skull with a trephine at the place of fracture, which might have relieved some of these cases could not have benefited the others. In cases I. and II. the sanguineous effusion was situated immediately beneath the cracked part of the skull, and being limited in extent could readily have been got at and removed by the operation of trephining; but in case III. the seat of the extravasation was underneath the dura mater, and therefore the operation of trephining alone could not have proved beneficial; moreover, if the cavity of the arachnoid had been opened by incising the dura mater at the trephine-hole it would not have done any good, for the effused blood was spread out over a wide space in the arachnoid cavity, and likewise in the sulci of both cerebral hemispheres under the visceral arachnoid membrane, so that it could not have been taken out by this or by any other operative procedure. So also the cerebral abscess in case IV. could not have been successfully evacuated by this or by any other operation.

Moreover, the surgeon's embarrassment is increased not a little in treating cases such as the foregoing, by the fact that he has no means of diagnosing with certainty the precise seat of the extravasation or the abscess, unless he trephines the skull, and, in many cases, incises the dura mater. Now, while it is true that in a large majority of the instances where linear fracture of the skull is complicated with compression of the brain from extravasated blood, the effusion is found between the bone and the dura mater, it is also true that in a very considerable majority of all the instances where compression of the brain is caused by blood extravasated

in consequence of injury, whether the skull be fractured or not, the effused blood is found not between the bone and the dura mater, but underneath that membrane in the arachnoid cavity and in the meshes of the pia mater beneath the visceral arachnoid, where it cannot be successfully reached by any operative procedure. The surgeon must therefore be able to diagnose linear fracture of the skull before he can turn these facts to any practical account. What are the signs which would enable him to recognize this form of injury? There is no depression, or displacement, or abnormal mobility of the broken bone in cases of fissured fracture of the cranium. Indeed, there is no external sign whatever by which the surgeon can recognize that lesion, short of laying the skull bare and exposing the fissure itself to view; and hence it is considered good practice by many surgeons, in cases of compression of the brain from extravasated blood where the extravasation is thought to have been caused by linear fracture of the cranial vault, to expose the bone at the place of injury by incising the scalp crucially, and dissecting up the flaps so as to bring to light the fissure if it be really present,

And, inasmuch as the diagnosis of the various lesions with which linear fractures of the skull may be complicated is involved in a great deal of obscurity and doubt, even so that kind of fracture when known to be present cannot always be treated on a fixed plan, but, generally, each case should be managed in accordance with the peculiar symptoms and peculiar features which it presents.

Firstly, the insensibility caused by concussion or contusion must be carefully distinguished from that which results from compression of the brain, which can generally be done without much difficulty, since the former appears as soon as the injury is inflicted, while the comatose stupor of compression usually does not appear until some little time has elapsed. In exceptional cases, however, the insensibility of cerebral concussion runs into the coma of cerebral compression, without the patient's recovering consciousness for one moment, as it did in cases I. and II.; and in such instances the differential diagnosis between concussion and compression of the brain becomes far more difficult. Sometimes, even in such cases, the occurrence of hemiplegia, beginning at some time more or less considerable after the casualty, and involving the side of the body opposite to the seat of cranial injury, and gradually increasing in extent and severity, may enable the surgeon to perceive the advent of compression of the brain from extravasated blood; and hence in all cases of this sort the symptoms of paralysis should be carefully sought for, and the precise time of their appearance noted, in distortions of the face and extremities of the patient.

But, as soon as the surgeon becomes satisfied that the compression of the brain is occurring from effusion of blood, he should endeavour to stay such effusion by keeping the patient at rest in bed with his head in an elevated position, by the application of ice to the head, and by venesection

if his pulse is strong. The general blood-letting should be repeated if the pulse rises again before the symptoms of paralysis, or the cerebral hemorrhage which produces them, have ceased to advance. Perhaps the fluid extract of ergot, in doses of twenty or thirty minims repeated at short intervals, would also prove useful. Anyhow the administration of this remedy would, in most cases, do no harm. After the hemorrhage has ceased, the treatment should be so conducted as to promote the absorption of clot on the one hand, and to prevent the occurrence of inflammation of the membranes and substance of the brain on the other. To this end the patient should be kept at perfect rest, the application of cold to his head should be continued, the diet should be meagre, and if headache with fever or delirium or convulsions should supervene, blood should be abstracted locally with leeches or cups, and aconite in full doses, together with mercurial or saline purgatives, should be administered. If, however, these symptoms of meningitis and cerebritis should be speedily followed by profound coma and deeper paralysis, it would generally denote that the brain is suffering from fresh compression which at this stage of the disorder is usually caused by the exudation of serum from the inflamed meninges, and the employment of counterirritants, such as large blisters on the nape of the neck, and the exhibition of potassium or sodium iodide in doses of ten grains every four hours, with a view to procure the absorption of the inflammatory effusion. But if the symptoms of meningeal and cerebral irritation are followed after a longer interval, especially one of several days' duration, by the symptoms of a fresh cerebral compression, it generally denotes the occurrence of intra-cranial suppuration, and that purulent matter has been formed between the skull and the dura mater, or in the meninges, or in the substance of the brain itself; or, in other words, that there is an intra-cranial abscess from which recovery is impossible unless its contents can be discharged externally, and thus the great nervous centres become relieved from the compression it engenders.

There are, then, two distinct pathological conditions, both of which produce compression of the brain that may demand the operation of trephining as a measure of last resort in connection with linear fracture of the skull. One of them is intra-cranial abscess, and the other intra-cranial hemorrhage. When, therefore, in cases belonging to the above categories the symptoms of cerebral compression continue to grow more strongly marked and alarming, notwithstanding the employment of the various measures above stated for relief from intra-cranial hemorrhage and intra-cranial abscess, it becomes the duty of the surgeon to expose the surface of the skull by suitable incisions of the scalp at the place of injury, without further delay, and to apply the crown of a trephine over the line of fissure at the spot where the bruise is most strongly marked, or where the pericranium is found to be detached; if he fails to find blood or pus collected between the cranium and the dura mater, and at the same time ob-

serves the dura mater to bulge up into the trephine-hole, and to be destitute of pulsation and perhaps also to be discoloured, he should puncture that membrane in order to procure the discharge of the matter causing such bulging; if he still fails to find the cause of the compression, and at the same time observes the cerebral convolutions to be flattened and otherwise altered in appearance as they would be by an abscess of considerable size situated in the brain-substance underneath them, he should make a suitable incision into the brain-substance also for the purpose of evacuating such cerebral abscess. By employing the trephine and the bistoury in this manner in treating linear fractures of the skull and their consequences, the surgeon will never injure his patients, but, on the contrary, will sometimes rescue them from otherwise certain death.

Furthermore, two examples of necrosis following fissured fracture of the cranium are reported in the Med. and Surg. History of the British Army during the Crimean War. The following is a brief abstract of them:—

CASE X. Wm. W., aged 20, wounded on Sept. 8th by shell; admitted at the Castle on Oct. 24th. On examination, a fissured fracture of the upper part of the frontal bone was detected, and a portion was felt to be dead. No head symptoms were present. On Nov. 10th, the necrosed bone having become loose was removed in one piece with forceps; it was found to be a portion of the external table about the size of a sixpence, and contained a fissure in its centre into which some hair had been firmly impacted. He recovered, and returned to his duty on Dec. 20th. (*Loc. cit.* p. 289.)

CASE XI. M. C., wounded on June 7th, probably by shell; admitted at the Castle on June 17th, having a lacerated wound of the scalp, at the vertex, nearly in the middle line. The bone was bared to the extent of an inch, and fissured. He had thirst and slight heat of skin, but the pulse was quiet. The right pupil was larger than the left. On the 25th the pupils had become symmetrical, and the pulse remained quiet, but he complained considerably of headache. On the 27th, a portion of the external table was loose, and was removed with forceps. The wound healed, and he went to England apparently well on July 28th, but still complaining of headache on exposure to the sun. (*Loc. cit.* p. 289.)

In both of these cases the fissure was limited to the external table, and was followed in due time by necrosis, and it is probable that the necrosis itself was caused by the contusion rather than the fracture which the injured bones had sustained.

To briefly summarize: Linear or fissured fractures of the skull may destroy life by rupturing the meningeal arteries, thus causing extravasation of blood between the bone and the dura mater, and fatal compression of the brain; or by inducing meningitis from irritating the dura mater with fragments of the inner table that have been depressed and driven into that membrane; or, again, the same blow which cracks the skull may burst open some cerebral artery and cause thereby meningeal hemorrhage and cerebral compression of a fatal character; or the same blow that breaks the skull may bruise and ecchymose the cerebral substance also, and thus excite cerebral inflammation and cerebral abscess. Traumatic meningitis, and the suppuration resulting from it, may be either diffused or circumscribed. Among the most important of the remedial measures are rest,

purgatives, the application of ice to the head, and the timely employment of the trephine, the indications for the use of which have been set forth above. Sometimes a linear fracture is followed by necrosis.

2. *Simple Fractures of the Skull with Displacement of the Fragments.*—Fractures of the cranial or of any other bones are called simple whenever the soft parts covering them do not exhibit solution of continuity corresponding to the osseous breach. Injuries of the skull belonging to this class are of frequent occurrence in civil life; and of great practical importance on account of the dangerous symptoms and disastrous consequences with which they are often attended. They occur in connection with a considerable variety of the casualties to which man is exposed. Among the most common of the causes which produce displaced fractures of the skull of a simple character, are 1. Blows on the head with clubs, slung-shots, stones, brick-bats, and various other blunt instruments; 2. Falling bodies and bodies hurled through the air striking against the head; 3. Kicks of animals; 4. Falls on the head, as happens to equestrians when thrown from the saddle; as happens also in falling down stairs, etc.; 5. Railway accidents. Fractures of the skull, in general, vary considerably according to the way in which they are produced, *i. e.*, in accordance with their causation. Thus, it was observed among our soldiers during the late war of the rebellion, that fissures or long linear fractures with little depression, as a general rule, characterized the fractures of the skull from falls or railroad accidents, while extensive splintering of the internal table was a very frequent consequence of blows from blunt instruments. (*Loc. cit.* p. 68.)

The diagnosis of this form of injury is generally not difficult. The displacement of the broken bone usually consists of depression, *i. e.*, the force which causes fracture also drives the fragments below the normal level, and in most cases the broken pieces can readily be felt to be in an abnormal position and beneath the level of the surrounding bone. There are, however, two sources of possible error against which special precautions should be taken. The first of them is found in those cases of contusion of the scalp wherein the occipito-frontalis is crushed in such a way as to afford a sharply-defined margin to the disintegrated portion that bears a very close resemblance to the margin of a depressed fracture, and the other is met with in those rare cases wherein the fibres of the temporal muscle are crushed and disintegrated in a similar manner, and with a similar result, an instance of which was reported by the writer in the No. of this Journal for April, 1879. The maxim which obtains in military affairs, *viz.*, to be forewarned is to be forearmed, obtains also in surgery. In some cases of fracture belonging to this category the amount of depression is but slight, while in others it is very considerable as it was in the following example:—

CASE XII. *Simple Comminuted Fracture of the Frontal Bone of great extent with much Depression; Recovery without Operation.*—John S., aged

about 30, of good constitution, accidentally received a tremendous blow upon his forehead from a sledge-hammer weighing fourteen pounds, on the afternoon of June 18, 1859, which struck him down to earth. He was picked up in a state of complete insensibility and carried home in that condition. On that evening I saw him shortly after dark in consultation with Dr. David W. Patrick. He then lay in bed as if asleep, breathing slowly, regularly, and somewhat stertorously. On examination we found that the hammer had struck the os frontis upon and above the right frontal eminence, contusing the scalp, fracturing the bone extensively, and depressing the fragments more than one inch by measure at the middle of the seat of fracture. We also found that the bone was badly shattered upward and backward to the neighbourhood of the coronal suture, and that a fissure with slight displacement extended downward across the superciliary and supra-orbital ridges of the same (*i. e.*, the right) side into the socket of the eye. The corresponding (*i. e.*, the right) eyelids were greatly swelled and blackened by ecchymosis. On forcibly separating the lids this eye was found to be more prominent than the left one, as if it were thrust forward by blood extravasated behind it. The right pupil was widely dilated and insensible to light. The conjunctiva of the same eye was blackened by ecchymosis. Besides contusion, the scalp suffered somewhat from laceration at the seat of fracture, caused apparently by the edges of the hammer, but the lacerations did not extend all the way through the scalp to the broken skull so as to make the fracture compound. The cavity formed by the depression of the fragments was cup-shaped, and Dr. Patrick estimated that it would hold four fluidounces, an opinion in which I fully concurred. The patient could be partially roused from the stupor in which he lay, but he sank off to sleep again directly on ceasing to disturb him. His pulse was full, regular, and beating about 110 times per minute. His surface was warm, showing that he had reacted well from the shock. I strongly suspect, however, that some whiskey had been given him before our visit. The left side of his face was paralyzed, the mouth being drawn toward the right side. The tip of the tongue when protruded turned toward the left side. The whole of the left side of his body was paralyzed as to motion, but not as to sensation. He swallowed well, but could not articulate. I was informed that the depression was observed to be considerably greater immediately after the fracture occurred than it was at the time of our visit, and that the fragments had been slowly rising.

Ordered his hair to be cut off, the seat of injury and the parts around it to be shaved, and his head to be kept constantly wet with cold water; to take internally tinct. digitalis, gtt. x every four hours, and magnesia sulph. ℥j also every four hours until his bowels should operate freely. Directed further that he should be kept at rest and free from noise, and that he should be put on a low diet. I declined to perform the operation of trephining, and likewise to attempt to elevate the depressed pieces of bone, unless the symptoms of compression of the brain should become more marked and threatening, *i. e.*, unless the coma should grow more profound.

June 19th. Stupor somewhat diminished; pulse has fallen to about sixty; in other respects the patient's condition remains unchanged; he retains urine and feces well; treatment to be continued; repeat the Epsom salt in the evening until free catharsis is obtained.

20th. Stupor still less than yesterday. During our visit he frequently placed his unparalyzed hand upon the fracture and upon the right side of his head, and indicated by other signs, for he could not utter any articulate words, that he had severe pain at the seat of fracture; pulse about 60;

skin in good condition. Ordered tinct. aconiti radiceis, gtt. ij to be given every four hours, and a powder consisting of hydrarg. chlorid. mite gr. $\frac{1}{2}$ with pulv. opii gr. $\frac{1}{4}$ to be administered every six hours; cold water to head and a low diet to be continued; rest and quietude to be carefully maintained; bowels to be moved in the evening with magnesia sulph. if they do not act spontaneously before that time.

21st. Patient appeared brighter, but the headache continued; the left hemiplegia remained unchanged. Ordered the aconite, the mercury, and the cold water to head to be continued; rest and freedom from noise to be strictly maintained; the secretion of urine being scanty he was directed to have spt. æther. nitros. as a diuretic; Epsom salt in the evening.

22d. Applied a fly-blister five inches square to the nape of his neck; other remedial measures unchanged. From this time he mended steadily.

27th. His headache was increased; applied a fly-blister behind his right ear. Directed the dose of calomel to be reduced to gr. $\frac{1}{4}$ every six hours, in order that salivation might not be induced: the aconite and cold water to be continued; magnesia sulph. if his bowels are not freely opened without it every day. Under this plan of treatment he steadily improved.

July 6th. Another large blister was applied to the back of his neck.

11th. A seton was inserted in the back of his neck. He was now able to sit up a good part of the time.

20th. He was discharged from treatment. He had recovered from hemiplegia so much as to walk with but little difficulty. His blackened and protruded right eye had resumed a natural position and appearance, and the sight had returned. No signs of facial palsy remained visible, unless he attempted to laugh, when the mouth was observed to be still drawn somewhat towards the left side. The fragments of broken bone still remained much depressed, but not so much, however, as they were found to be at our first visit. He still had much difficulty in speaking or uttering articulate words, but appeared to be cheerful and sensible.

Two years afterwards I again saw this man. His general health was very good. He had improved much in respect to speech, but he still articulated slowly and hesitatingly. More than four years after the injury Dr. Patrick reported him to be in good health; and stated further that his speech was not yet entirely restored, and that he was thought to be not quite so bright as he was before the injury.

March 8, 1879. A neighbour of this man informs me that he is well and hearty, and able to do a good day's work; and that he does not perceptibly grow any weaker in intellect.

Comments.—The history of this case illustrates very well the leading points in the symptomatology and treatment of simple fractures of the cranium with much displacement, the results of great violence.

Although the fragments of broken skull were greatly depressed or driven inward by the blow, and thus compressed the brain so much as to occasion hemiplegia, it was not necessary to raise them by any operative procedure, for they rose up spontaneously, *i. e.*, from the upward pressure constantly exerted upon them by the brain itself, most of the way back to their original position. Thus the brain was, to great extent, relieved from the symptoms of compression by the operation of natural forces, and in time adapted itself to the new condition of things so well that the hemiplegia disappeared.

The precept is also well exemplified by the history of this case which should guide the surgeon in regard to employing the trephine and elevator for the purpose of raising up the depressed bone in all strictly analogous cases. The writer deferred the employment of any operative procedure in this case, because the symptoms of cerebral compression, such, for example, as coma and paralysis, instead of growing more profound and alarming, gradually became lighter, and thus ultimately disappeared. But if, on the other hand, no improvement in these symptoms had taken place, or if the comatose stupor and the paralysis had grown more strongly marked in spite of the remedial measures that were employed, it would then have become the writer's duty without delay to expose the broken bone by suitable incisions, to apply the trephine, to raise the depressed pieces, to remove the extravasated blood, and thus to relieve the great nervous centres from a state of anæmia caused by compression which must sooner or later have proved fatal, unless these measures were employed. In other words, the operation of trephining should be practised rather as a *dernier* than as a *premier ressort* in cases of extensive comminution, such as the one just related, and mainly with a view to relieve the brain from compression which cannot otherwise be removed.

Notwithstanding the great compass of the fracture and depression of the fragments, and the great amount of injury in the shape of contusion, etc., which must have been sustained by the underlying portions of the membranes and substance of the brain, the tendency to inflammation therein was successfully combated by the employment of rest, quietude, and a low diet, by the application of cold to the head, by the administration of saline purgatives, digitalis, and aconite, and, at a later period, by calomel and opium in small doses as an antiphlogistic, simultaneously with vigorous counter-irritation by repeated blistering, and by seton. The therapeutic value of all these remedial measures became very evident and very strongly marked as this case rapidly progressed, much more rapidly than we had dared to hope, towards recovery. Moreover, after the lapse of almost twenty years, this man is still found to be free from all evidence of softening or any other organic disease of his brain, and of its membranes.

Simple fracture of the cranial vault with displacement may be accompanied by laceration of the meningeal arteries with extravasation of blood between the skull and the dura mater, by laceration of some cerebral artery with effusion of blood into the arachnoid cavity and into the meshes of the pia mater beneath the visceral arachnoid, and by contusion with ecchymosis of the convolutions and substance of the brain beneath the seat of fracture; but these topics have been so fully discussed under the head of linear or fissured fracture as not to require special consideration here.

The displacement in cases of simple comminuted fracture of the cranial vault almost always consists in depression of the fragments. The force which breaks the bone drives also the broken pieces before it. The

amount of the depression varies of course with the degree of the force itself, and the way and direction in which it is applied. Sometimes, however, it happens that while the fragments are driven inward or depressed at one part of the fracture, they are forced outward or raised above the normal level at another part of the fracture, as they were in the following instance, wherein a soldier during the late war of the rebellion, received a simple displaced fracture of the frontal bone, of great extent, from a terrible blow struck by some large fragment of an exploding shell.

CASE XIII. Private Augustus Z—, Fifth N. Y. Artillery, aged 35, was wounded in the head by the explosion of a shell in battle, at Spottsylvania Court House, Va., on May 17, 1864, and brought to the Stanton Hospital, at Washington, of which the writer had charge, on May 20th, three days after his injuries were received. He was still insensible. His forehead and the upper part of his face were much swollen and ecchymosed from contusion; the right half considerably more than the left. The pupils of both eyes were contracted. He lay in bed upon his back in deep stupor, from which, however, he could be partially roused by loud and repeated calls. He would then mutter a few incoherent words, and immediately go to sleep again. No part of his body was paralyzed. His respirations were deep, but not snoring, regular also, and occasionally he heaved a deep sigh. His pulse was frequent and feeble. He passed his urine in bed, without knowing it.

On examining the skull at the place of injury, it was found that a large triangular piece of the frontal bone, on the right side, was fractured and displaced, without, however, any solution of the continuity of the scalp. The skin was extensively blackened by ecchymosis. The base of this triangular piece of broken bone was constituted by the upper border of the right orbit; its apex was found at the coronal suture. The inner line of fracture extended from the internal angular process of the os frontis on the right side, upward and somewhat outward to the coronal suture. The outer line of fracture extended from the margin of the orbit, half an inch to the inner side, or within the external angular process, directly upward toward the vertex, until it met the line of fracture just described, at or near the coronal suture. This piece of bone was depressed considerably at its apex and upper part and inner side; but its base or orbital margin was pushed forward somewhat (about one-eighth of an inch), *i. e.*, it was elevated to that distance. As already stated, the fracture was not compound. The right eye was also pushed forward a good deal, and thus made to protrude, by blood extravasated into the orbit behind it. The sclerotic and palpebral conjunctivæ had a dark brown colour from ecchymosis. His head was warmer than natural. The symptoms which he exhibited were mainly those of concussion, contusion, and irritation of the brain. Ordered his hair to be clipped, the ice-bag to be kept on his head, a state of quietude to be maintained, cleanliness as to defilement with urine, etc., and a milk diet with essence of beef.

May 24th. His bowels being confined, ordered an enema.

25th. The condition of the injured parts remains about the same, but the pupils have become normal in size, and they contract readily on exposure to light. He still continues to lie unconscious, and swallows milk and beef-essence, as it were, mechanically. Enema to be repeated.

27th. The swelling and ecchymosis are gradually subsiding, but he still lies unconscious, and his pulse continues frequent and feeble.

30th. He opens his eyes and listens when called in a loud voice, but makes no attempt to reply.

31st. The swelling and ecchymosis continue to subside, but the left pupil is slightly larger than the right one.

June 1st. The left pupil is dilated more than it was on yesterday. The pulse continues frequent, but it is fuller and stronger, and has assumed an inflammatory character. The right eye is still much too prominent from blood effused behind it. Prescribed, pil. hydrarg. gr. ij, every two hours, extract. aconiti fluid, gtt. j, every six hours, and emplastr. cantharidis to nape of neck. The ice-bag to be continued on the head.

4th. His bowels are confined. Ordered a saline cathartic. The left pupil is still dilated, but the amount is less. The right pupil is sensitive to light. Directed the other treatment to be continued unchanged.

6th. His bowels are again confined. Saline cathartic to be repeated.

15th. His consciousness is slowly returning. The swelling and ecchymosis have nearly disappeared. Same treatment to be continued.

26th. So much improved that all medication was suspended.

July 13th. Prescribed magnes. sulph. $\mathfrak{z}$ j for relief of constipation.

31st. His bowels are again confined; administered magnes. sulph. $\mathfrak{z}$ j. Consciousness is now completely restored, and he is bright and cheerful.

August 24th. His bowels have continued to be constipated since last report, and saline cathartics have, from time to time, been administered. He complains of having constant headache, and I also notice that he is slowly emaciating. Put a seton in the back of his neck.

Sept. 21st. He feels better, and his headache is growing less.

28th. His countenance is expressive of much pain in the head, and he says the headache is about the same or rather worse. He continues slowly to emaciate. His step is uncertain and tottering, and he inclines to drag his toes in walking. Renewed the seton, and prescribed: R. Hydrarg. chlorid. corrosiv. gr. ij; Tinct. cinchonæ comp. $\mathfrak{z}$ iv. *Signa.* Take one teaspoonful, three times a day, mixed in water.

Oct. 5th. He continues to emaciate very slowly, but his power of locomotion is improving. Ordered the same treatment to be continued.

19th. His countenance now expresses less suffering, his gait is slowly improving, and he has stopped losing flesh. No change in treatment.

28th. He says the headache continues to grow better, and his countenance also looks better. He is also obviously improving in flesh and strength. Directed the bichloride and the seton to be continued.

Shortly afterwards he was mustered out of the service, his term of enlistment having expired, and he passed beyond the range of our observation. What ultimately became of him is unknown to the writer.

Comments.—This case resembles the last in several important particulars. Both patients were in the prime of life. Both received a simple but very extensive fracture of the right part of the frontal bone with displacement. In both the accidents which caused the fractures were of such a nature and severity that *a priori*, escape from death, occurring on the spot or soon afterwards, was scarcely to be expected. Still both patients after long-continued treatment made pretty fair recoveries.

This case also possesses several features which are worthy of special notice. For example, the broken bone was depressed at its upper and inner part, while it was displaced outwards at its inferior part or margin,

a kind of displacement which does not often occur. The case is, likewise, remarkable for the great length of time wherein the patient lay in a state of more or less profound stupor, a period of more than fourteen days, and yet he recovered his senses completely in the end. During this long interval, he lay utterly unconscious, and swallowed automatically whatever was placed in his mouth.

Again, this case attests the great value which ice possesses, when applied to the head, in controlling cerebral irritation, hyperæmia, and inflammation, resulting from cerebral contusion. I believe that this man could not have been saved without the free employment of ice. As he slowly mended, the application of the ice-bag to his head was suspended several times on the supposition that further use was unnecessary, but on each of these occasions its employment had soon to be resumed, because of the reappearance of dangerous head-symptoms; and thus we were compelled to keep the ice-bag on his head almost constantly, more than four weeks, certainly a remarkable, if not an unexampled length of time for persevering in the application of ice to the head. In this way we probably prevented the occurrence of cerebral abscess, for ice when continuously applied to injured parts exerts a singular influence in the way of retarding, and preventing suppuration. I have several times seen gunshot wounds of the periarticular tissues of the knee-joint, which were treated with ice continuously applied for the purpose of preventing the spread of inflammation to the joint itself, heal by granulation with the accompaniment of but very little or of hardly any suppuration. It is unnecessary to shave the scalp or any part thereof in all cases of simple fracture when the ice-bag is to be applied, and perhaps it is even better not to shave the scalp under such circumstances, for the hair when cropped short performs very well the office of a compress interposed between the cold ice-bag and the sensitive scalp. Moreover, in all cases of insensibility where ice is applied to the head its effects upon the pulse, cranial integuments, etc., should be closely watched, lest harm be done by the incautious employment of so powerful an agent. Finally, this case shows well the great benefit that may be derived from the long-continued use of counter-irritants, and the long-continued administration of the bichloride of mercury in the way of relieving the sequelæ of traumatic irritation, hyperæmia, and inflammation of the brain and its membranes.

But the plan of treatment just described does not succeed in every case belonging to this category, for while it saves some patients who could not otherwise be rescued from the consequence of cerebral inflammation following comminuted fracture of the skull, it does not avail to save other patients similarly injured. The following example is to the point:—

CASE XIV. M. L—, aged 33, was struck on the head with a club, on July 1, 1864. He was taken to hospital the same day, and on July 4th was transferred to a hospital at Washington, of which the writer was then surgeon-in-charge. On examining him it was found that he had sustained a comminuted

fracture of the right temporal bone with depression, that this fracture was not compound, and that it was not advisable to undertake any operative procedure. Accordingly, he was treated with rest, and ice applied to the head, with purgatives, antiphlogistics, counter-irritants, and meagre diet, but in spite of all this he died of cerebral inflammation, on July 14th. (*Med. and Surg. Hist. of War of Rebellion*, Surg. Vol., Part I, p. 49.)

CASE XV. James R— was struck by a stone, on May 3, 1865, receiving a depressed fracture of the skull. He was admitted to hospital on May 7th, in a comatose state. He remained in this condition until May 9th, when he was placed under ether, and had the trephine applied, and the depressed bone elevated. Good reaction occurred, and simple dressings were employed. Erysipelas supervened, but it was successfully combated by chloride of iron. The patient improved rapidly, the wound cicatrized, and he returned to duty well, on June 29, 1865. (*Ibid.* p. 59.)

CASE XVI. Patrick H. G— received a blow on the left side of the head from a slung-shot, on May 23, 1863. He was treated by a private physician until June 3d, when he was admitted into hospital. Twenty-four hours after admission he had a spasm of the right side, and, upon examination, there was found to be a depressed fracture of the skull. The scalp was laid open, trephining was performed, and the depressed portions of bone were removed. The convulsions ceased after the operation. The patient progressed favorably, and was discharged from service on Sept. 21, 1863, for hemiplegia. (*Ibid.* p. 57.)

Comments.—Both of these examples of trephining for simple depressed fractures of the cranial vault are very interesting and instructive. In the first of them the symptoms of cerebral compression were caused not by intra-cranial hemorrhage, but by displacement inward of the broken bone itself. This was clearly shown by the fact that no improvement of those symptoms was observed during the interval of six days which elapsed between the reception of the fracture and the performance of trephining, for these symptoms would have abated, at least considerably during the lapse of so long an interval, if they had been caused by blood-clot, since the absorption of much of it would meanwhile have taken place. This man's recovery was not possible, it became obvious after this long delay, until the pressure was taken off his brain, by raising up the depressed portion of bone. The rule of surgery in regard to using the trephine, etc., in cases of simple fracture of the skull with depression, should therefore be, that when the symptoms of cerebral compression have continued unchanged and undiminished for five or six days, as they did in the case above related, or for two, three or four days, according to the special features of the case, the surgeon should proceed to expose the fractured bone by suitable incisions, to apply the trephine, and to elevate the depressed portion, without longer waiting. The main point in practice is to be convinced that the head-symptoms (coma) are due to cerebral compression, and that the compression itself is produced by displacement inward upon the brain of the broken bone, before proceeding to operate. As soon as it becomes clear that the depressed position of the broken bone is the real fault, the displacement should at once be corrected, with the aid of the trephine, elevator, etc., for in such cases recovery cannot take place without such operative interference.

Furthermore, the operation of trephining should be performed in cases

of simple fracture of the cranial vault, whether linear or depressed, whenever symptoms of cerebral compression from extravasated blood, such as hemiplegia on the side of body opposite to the injured side of head and stupor and stertor and coma, make their appearance after the patient has recovered more or less completely from cerebral concussion, and the extravasated blood should then be removed. In such cases the source of the hemorrhage is usually some ruptured branch of the middle meningeal artery, and the effused blood is found between the bone and the dura mater. Thus Mr. Hewett states that out of thirty-one cases of fracture of the skull, with extensive extravasation, the blood proceeded from the middle meningeal artery or its branches in twenty-seven instances (*loc. cit.* p. 256). A collection of blood between the cranium and the dura mater can, not unfrequently, be reached and removed by trephining; especially when it forms beneath the anterior inferior part of the parietal bone, a frequent site for such collections. By so doing patients can be saved who would certainly perish unless operated on. Dr. Samuel Wilks has related the following case in point, wherein trephining was successfully employed to relieve the brain from compression by extravasated blood:—

CASE XVII. Ruptured Meningeal Artery; Hemiplegia; Trephining; Recovery.—A man was admitted under Mr. Cock's care in an insensible condition, having fallen from a height. He gradually recovered from the concussion, and remained sensible for some time, but in the night he was found in a deep coma, with stertorous breathing, and with insensible contracted pupils. The man seemed on the point of death, when Mr. Cock determined to trephine, being guided in the choice of locality by the fact that the left arm and leg were freely moved when they were pinched, whereas not the slightest motion could be excited in either of the limbs of the right side. A large clot of blood was removed; the stertor almost immediately ceased, and on the following day the man could move his right arm and leg freely. He shortly after resumed his work, and remained well for thirteen years, except that he had some fits towards the close of life. He at last died of apoplexy. (*Guy's Hospital Reports*, 1866, p. 194.)

After what has been said above it is, perhaps, scarcely necessary to add that simple fractures of the skull with depression, but without brain-symptoms, should be let alone, and merely watched; rest, quietude, and spare living, however, being enjoined, with the applications of cold to the head and the administration of purgatives until the appearance of cerebral symptoms shows that it has become advisable to trephine, etc. Under appropriate treatment, both general and local, many cases belonging to this category make good recoveries without operation.

3. Compound Fractures of the Skull with Displacement of the Fragments.—Fractures of the cranial bones attended with perforating wounds of the cranial integuments extending directly down to them, *i. e.*, compound fractures, like simple fractures, are frequently met with in both civil and military practice. Gunshot fractures of the skull, with some rare exceptions, are always compound. Of 105 cases of cranial fracture, other than gunshot or sabre-strokes, but the results of injuries common to the soldier and the civilian, such as railway accidents, falls, blows, from blunt

instruments, kicks of animals, the falling of trees, and masonry, and other like casualties, which were reported during our war of the rebellion, 43 were instances of compound, 46 of simple, and in 16 cases the reports are silent regarding this distinction. (*Loc. cit.* p. 67.)

CASE XVIII. Compound Depressed Fracture with much Comminution; Dura Mater Lacerated; Hernia Cerebri; Encephalitis; Death; Autopsy.—John S., coloured, aged 10, died about two weeks after receiving a compound comminuted fracture of the skull, with much depression, from a block of wood thrown out of a window. Depressed fragments were elevated, and those that were loose removed. The dura mater was torn through, and the brain-substance injured. Cerebral hernia with inflammation of the membranes and substance of the brain ensued which proved fatal. The patient was most of the time unconscious, and for several days had frequent convulsions.

Autopsy, by the writer, on April 16th. There was a hole in the scalp on the left side of the head, above the ear, as large as a Spanish dollar. There was also a hole in the skull as large as a half dollar. The dura mater was penetrated by an opening through which the brain protruded. The physician who attended deceased informed me that he removed thirteen pieces of the skull shortly after the accident, some of which had been driven through the dura mater. On removing the skullcap it was found that the dura mater adhered to the bone around the place of fracture more strongly than elsewhere. The superior longitudinal sinus contained a long cord-shaped coagulum of fibrin, having a yellowish-white color. In the longitudinal fissure of the brain a considerable quantity of purulent matter was found spread over the free surface of the visceral arachnoid membrane, and likewise diffused beneath that membrane in the meshes of the pia mater. The pus in the pia mater constituted a lamina underneath which the cortical substance of the brain exhibited more or less softening. About the optic foramina, the base of the cerebellum, and the medulla oblongata an abundant quantity of purulent matter was found on the free surface of the visceral arachnoid. The lateral ventricles contained a large spoonful of sero-purulent effusion. The plexus choroideus was much thickened by exudation having a semi-purulent appearance. The left hemisphere of the cerebrum was much disorganized beneath the seat of fracture down to the lateral ventricle. There was extensive loss of substance, and the portion of it that had not escaped was completely broken down in the neighbourhood of the fracture. The portion of it in the neighbourhood of the lateral ventricle was diffuent and discoloured with blood.

Comments.—The so-called fungus cerebri in this case obviously consisted for the most part of brain-tissue disorganized by the inflammatory process, or of a new morbid outgrowth therefrom. With regard to fungus cerebri we may state generally that in a large majority of the cases the protruding mass, when examined microscopically, is found to contain no nerve-fibres and no nerve-cells, but to consist mainly of granular matter, so that ere the brain-tissue itself is extruded, it has generally become extensively disorganized by the inflammatory process.

The cause of death in this case was suppurative inflammation of the membranes and substance of the brain. The membranes principally involved were the arachnoid and pia mater; and it is a rather curious cir-

cumstance that the meningitis spread to the ventricles and involved the plexus choroideus. Meningo-cerebral inflammation, or encephalitis, is a very frequent cause of death in the cases of cranial fracture that are met with in civil as well as in military practice. Thus of 57 fatal cases of cranial fracture produced by the common accidents of civil life, that were reported during our war of the rebellion, encephalitis was the cause of death in *ten*, and abscess of the brain in *six* instances, making altogether 16 cases wherein the inflammatory sequelæ of cranial fractures proved mortal (*loc. cit.* p. 67). Patients belonging to this category, however, are sometimes saved by trephining. The following example illustrates well this point.

CASE XIX. Jesse S., coloured, aged 18, rolled, while asleep in a stable loft, and fell some twelve feet to the floor, striking on his head. He was found in the morning on the floor cold and insensible. Under the use of restoratives he revived, and was carried to hospital. There it was found that he had compound depressed fracture of the right parietal bone; but, as the patient's general condition was favourable, sensibility being restored, and mental faculties normal, it was decided to await further developments. For twelve days nothing of importance occurred, when he complained of increased headache, and a few hours subsequently had severe convulsions. On the next day he was about the same as usual, except that his headache was increased. Then, under ether, the original wound was enlarged, the trephine applied, and a disk of bone removed, to which most of the depressed fragments were attached. On removing the bone, pus gushed out copiously. At the upper posterior part of the perforation the inner table was detached three-fourths of an inch more than the outer. This fragment was, with some difficulty, removed with strong forceps. After the operation he complained of intolerable pain for which morphia in very large doses was administered. His diet was restricted to bread and milk in small quantities. In three days after the operation the brain commenced to protrude, and by the tenth day the protrusion had acquired the size and shape of half a hen's egg. To reduce the protrusion a compress and retentive bandage were applied, but violent convulsions immediately ensued; and although this dressing was instantly removed, violent convulsive paroxysms recurred during the night, not less than fifteen or twenty times. On the next day the patient was hanging between life and death, but he rallied gradually, and, strange to say, he had no more pain in his head after the convulsions subsided. Convalescence proceeded rapidly; the protrusion subsided; a dense cicatrix covered the aperture in the skull; and the patient recovered without impairment of mental faculties or motor powers. (*Loc. cit.* pp. 59, 60.)

Again, compression of the brain occasioned by the depressed fragments of the broken skull is another cause of death in cases of cranial fracture, which is frequently met with in civil practice. For example, out of the 57 fatal cases of cranial fracture produced by accidents that are common in civil life, mentioned above, compression of the brain from fragments of bone was likewise the cause of death in 16 instances (*loc. cit.* p. 67). But, patients belonging to this class are not unfrequently saved by the timely performance of the operation of trephining. Of two cases of this sort brief abstracts are given.

CASE XX. A. B. P., received a lacerated wound of the frontal region with fracture and depression, from the kick of a horse. He was admitted to hospital on the same day in a semi-comatose condition. Soon after admission the operation of trephining was performed, and the depressed bone raised. He soon re-

acted. Tonics, stimulants, and low diet were ordered. He gradually improved, and was discharged cured thirteen months after injury. (*Loc. cit.* p. 58.)

CASE XXI. Henry B. fell a distance of twenty-four feet, striking upon the vertex. A scalp wound four inches long and fracture of both tables of the skull with depression for a space two inches in diameter, were produced. On admission to hospital his pulse was imperceptible, and he lay groaning occasionally, his lower limbs moving spasmodically. The trephine was applied, but the depressed portion of bone could not be raised. A portion of the fractured skull was then removed with Hey's saw; after which the depressed portion was raised to its normal position, and the periosteum was brought back over the solution of continuity of the bone. The wound was then dressed with cold water. The after treatment was of stimulant and tonic description, with careful attention to bowels, and occasional opiates. Fifteen days after the operation, the patient was walking about the ward. The wound of the scalp was united: and a small spot over the trephined part was healing by granulation. (*Loc. cit.* pp. 55, 56.)

In the last case the depressed fragments were impacted so firmly and to such extent that it cost a good deal of trouble to elevate them. Besides these two examples, the Medical and Surgical History of our War of the Rebellion contains reports of eight additional cases in which cerebral compression caused by the depressed fragments of compound fractures of the skull, not produced by gunshot or sabre-stroke, but by common accidents, was successfully treated by surgical operations. In five of them the trephine was employed; in the other three the depressed fragments were raised with the elevator, or extracted with forceps, after enlarging the scalp-wounds by suitable incisions.

Furthermore, compression of the brain from extravasated blood is still another cause of death in cases of cranial fracture, which is frequently met with in civil practice. For example, of the 57 fatal cases above mentioned, that were reported during our civil war, where the fractures were not produced by gunshots nor by sabre-strokes, but by common accidents, compression of the brain from extravasated blood was the cause of death in 16 instances (*loc. cit.* p. 67). It is a singular coincidence that of these 57 fatal cases of cranial fracture, just 16 perished from inflammation of the membranes and substance of the brain, just 16 also perished from cerebral compression occasioned by the depressed fragments of bone, and just 16 likewise died of cerebral compression from extravasated blood. But patients who were in a bad way from effusions of blood between the skull and the dura mater, formed in consequence of lacerations of the middle meningeal artery or its branches, the result of cranial fractures, have sometimes been saved by perforating the skull with a trephine at the seat of the hemorrhage, and removing the effused blood. One instance belonging to this category we have already related (CASE XVII.).

Four successful cases of similar character are given by Quesnay in his observations upon the use of the trepan in doubtful cases (*Memoirs of the Royal Academy of Surgery*, Sydenham Soc.'s Ed., pp. 8, 12, 14, 21, 22).

A fifth case: Abernethy operated successfully on a boy, aged 14, hurt by falling on his head from a scaffold, and brought to hospital in apparently a dying state, with depressed fracture of anterior inferior angle of the parietal and part of the frontal bone. He applied the trephine and found a large quantity of

coagulated blood underneath the bone, which he completely removed after applying the trephine three times. The lad recovered his senses, and all the symptoms of compression passed away. (*Essay on Injuries of the Head*, pp. 24-27, London, 1797.)

A *sixth* case: In the year 1839, a man was struck with a spade just over the anterior inferior angle of the right parietal; and when he came to St. George's Hospital a few minutes afterwards, a compound fracture with depression of a small piece of the skull was detected, but there were no cerebral symptoms whatsoever. Shortly afterwards, however, the patient became heavy and stupid; and coma was gradually supervening, when Mr. Keate arrived, and at once proceeded to remove the depressed bone, whereupon a jet of blood spirted out from a large branch of the middle meningeal artery, and all the symptoms of compression were immediately relieved. (*Holmes's Surgery*, vol. ii. pp. 257, 258.)

A *seventh* case: In the year 1842, there was another case of the same kind at St. George's Hospital under the care of Mr. Tatum, in which the operation of trephining was equally successful. (*Ibid.* p. 258.)

Moreover, the examples furnished above show pretty clearly what the indications are for resorting to the use of the trephine in order to relieve the brain from pressure caused by blood effused between the skull and the dura mater, in cases of cranial fracture. They are the occurrence of coma after the symptoms of cerebral concussion have more or less completely passed away, especially when hemiplegia on the side of body opposite to the injured side of head, simultaneously appears; also, the continuance of coma and hemiplegia long after the symptoms due to cerebral concussion have disappeared, although the period of cerebral concussion has not been separated from that of cerebral compression by any intervening period of restored sensibility and consciousness. Sir Benjamin C. Brodie says:—

“Blood is seldom poured out in any considerable quantity between the dura mater and the bone, except in consequence of a laceration of the middle meningeal artery, or one of its principal branches; and it is very rare for this accident to occur, except as a consequence of fracture. If, therefore, we find the patient dying in a state of stupor, and, on examining the head, we discover a fracture, with or without depression, extending in the direction of the middle meningeal artery, although the existence of an extravasation on the surface of the dura mater is not thereby reduced to absolute certainty, it is rendered highly probable; and the surgeon, under the circumstances, would neglect his duty if he omitted to apply the trephine; and where no fracture is discovered, yet, if there is other evidence of the injury having fallen on that part of the cranium in which the middle meningeal artery is situated, the use of the trephine may be resorted to on speculation, rather than that the patient should be left to die without an attempt being made for his preservation.” (*Med. Chir. Trans.*, vol. xiv. p. 385.)

In such cases the blood-clots are generally found to be dense and tough. But should the symptoms of cerebral compression arise from traumatic extravasation of blood in the arachnoid cavity, they will be the same as those of blood collected on the outer surface of the dura mater between that membrane and the bone; and a surgeon may thus be led to apply the trephine on the supposition that the effused blood is in this situation. And now, supposing the trephine to have been thus applied, and no blood found between the skull and the dura mater, still the blood in the arachnoid cavity may chance to lie immediately under the spot, and the dura mater, of a bluish colour, may bulge up into the trephine-hole. Under such circum-

stances, blood in the arachnoid cavity has several times been let out by incising the dura mater, and the patient saved. When, however, there are no indications that the blood in the arachnoid cavity is under the trephine-hole, there is nothing to justify the surgeon in proceeding further. (*Prescott Hewett.*)

The dura mater should never be opened by the surgeon except for some very grave cause. Sir Benjamin C. Brodie, while assenting to this view, also held that there are some rare cases of sanguineous extravasation into the arachnoid cavity where puncturing the dura mater is positively demanded by the surgeon. He says:—

“We may regard it as a general rule, that an operation is not applicable to cases of compression of the brain from internal extravasation. But there are few general rules in surgery to which some exceptions may not be made. Let us suppose a case in which a considerable portion of bone has already been removed, in which the dura mater is seen exposed, of a blue colour, lifted up by a collection of blood beneath it, and bulging, as it were, into the aperture which has been made in the cranium. Are we justified in puncturing the dura mater for the purpose of allowing the extravasation to escape? Everything that we see of wounds of the dura mater tends to prove the very great danger of this kind of injury. The dura mater should never be wantonly punctured; but we cannot doubt that, in what may be regarded as desperate cases, it must be right to give the patient the chance, small as it may be, which the division of the dura mater affords him. The combination of circumstances which would lead to such an operation must be very rare, but it may occur, nevertheless, and the surgeon should be prepared to meet it.”

In support of this opinion he cites two cases:—

An infant of eighteen months, under the care of Chevalier, from a blow on the head, lay insensible, and was convulsed. There was no wound, but, the fontanelle appearing somewhat elevated, Chevalier raised the scalp from the membrane that forms it, and exposed the dura mater, beneath which the purple colour of the blood was plainly seen. He therefore made a careful puncture: “The blood issued at first with considerable force, spouting to the distance of a foot; three or four ounces of blood escaped; the symptoms were immediately relieved, and the child recovered.” The other case was that of a woman who, having fallen down the stairs of a cellar, came under Ogle’s care. He found her without wound, and lying as if in a fit of apoplexy, but “she flinched very much when pressure was made on one spot near the anterior superior angle of one of the parietal bones.” He incised the scalp, and trephined the skull. “The dura mater, of a dark colour, rose into the opening nearly as high as the external surface of the cranium.” He punctured it; this proceeding “was instantly followed by a stream or jet of blood which spirted out to the height of some feet. Immediately, on the blood being discharged, the woman, who until that moment had continued totally insensible, opened her eyes. After looking about her apparently amazed, she exclaimed, ‘What’s the matter? what are you doing with me?’ and was able to give a clear account of the manner in which the accident occurred. From this time she recovered without any untoward symptom.” (*Loc. cit.* pp. 388–391.)

In cases of cerebral compression, where the blood is effused between the skull and the dura mater, however, the extravasation is usually found to be thickened into a coagulum which is dense, tough, and hard to be removed. So much, then, concerning the very great frequency with which depression of the broken fragments, intracranial extravasation of blood, and traumatic inflammation of the membranes and substance of the brain,

are found to be the causes of death in cases of compound fracture of the skull in civil life; also concerning the operative procedures which we should employ in order to relieve the brain from fatal compression in such cases, together with the indications for their use.

But what is to be done in those cases of compound depressed fracture of the cranium where we find no symptoms of cerebral disturbance when we are called? Are we to operate at once, or await the development of threatening symptoms? The rule is, that we are to operate without delay. Compound fractures of the skull with depression very frequently lead, as shown by Sir Astley Cooper and Sir Benjamin C. Brodie, to intracranial suppuration; and hence the rule laid down by these celebrated surgeons that we are to operate in order to prevent the impending mischief. (*Med. Chirurg. Trans.*, vol. xiv. pp. 401, 402.) To this rule, however, some exceptions ought to be made. A slight depression, especially when it corresponds to the thicker parts of the injured bone, generally does not require an immediate operation. Neither does a deep in-driving of the bone over the frontal sinuses; but here it should be remembered that these sinuses do not begin to form until several years after birth. And when a compound fracture with depression does not come under the surgeon's care until some days after the accident, he generally should, if there are no signs of meningo-cerebral inflammation, delay to operate, and try other remedial measures; and all the more readily, if the depression is broad, and the fracture comminuted. From such injuries the patient sometimes recovers without the occurrence of intracranial inflammation. But in cases where the fracture is a punctured one, where sharp splinters of the inner table are driven down upon or into the dura mater, inflammation of the invaded parts, sooner or later, is almost invariably excited thereby. Of all compound fractures of the skull, the punctured fracture is on this account the most dangerous, and the one which most imperatively demands the prompt use of the trephine, and the elevator, and the bone forceps. (*Prescott Hewett.*) Several cases of punctured fracture, in which the trephine, etc., was successfully employed, will next be related.

CASE XXII. Punctured Fracture of Left Parietal; Trephining; Recovery.—T. M., aged 36, had on a soft hat, and was standing up in an iron mine, when a stone weighing about four pounds fell a distance of forty feet, and struck him on the head. He says the blow stunned him for a moment, but he did not become wholly insensible. The wound bled very freely for several hours. He had no nausea, or vomiting, but found he could not hear so well as usual. Ten days after the accident he was admitted to St. Vincent's Hospital, New York, where the writer saw him, at Prof. Gouley's instance, several times. Up to this time there had been no marked symptoms. On examination a small scalp-wound was found on the prominence of the left parietal, about three-fourths of an inch in length. The bone was fractured an inch in length and half an inch in width, and depressed about one-eighth of an inch. On the second day after admission, Prof. Gouley trephined the patient, and found the inner

table injured more extensively than the outer. The scalp bled very freely during the operation. For nearly three weeks the patient had no bad symptoms, when pain in the injured part of head became quite severe, followed with all the symptoms of cranial osteo-myelitis. Wet cups were applied to the left temple with some relief. The eye on the affected side was congested. The wound gradually filled up with granulations, except in one direction, where a probe could be passed under the pericranium for nearly three inches. The symptoms of osteo-myelitis gradually subsided, and the pericranium became again attached. The wound was nearly healed, no bone came away by exfoliation, although quite a large surface had been denuded. He left the hospital two months and one week after admission. I am indebted to Prof. Gouley for the foregoing account of his case. I think that potassium iodide, in full doses, was also administered for the cranial osteo-myelitis, and with benefit.

CASE XXIII. Punctured Fracture of Left Parietal; Trephining; Recovery.—D. C., 32 years of age, had on a soft hat, and was standing about seven feet from a building, which was sixty feet high, when a slate weighing about five pounds fell off the roof and struck him on the head. He fell on his knees, but did not become wholly unconscious. He soon recovered from the shock, had but little hemorrhage or pain, and no vomiting.

One week after the accident, he was admitted to St. Vincent's Hospital, N. Y., where the writer saw him several times at Prof. Gouley's instance. On examination a scalp wound was found on the prominence of the left parietal bone two inches in length, and the outer table was found to be slightly depressed, about one-sixteenth of an inch. Prof. Gouley trephined him on the second day after admission. The skull was extremely thick. The inner table was not depressed, but had on its inner surface a fissure about half an inch in length. There was but very little hemorrhage during the operation. No bad symptoms followed for about two weeks, except slight headache, and the wound made considerable progress toward healing. At this time a small portion of the outer table became loose and was taken away. Considerable of the pericranium became detached from the bone around the trephine hole. The headache became severe and continued for several days. Wet cups were applied to the left temple with some relief. The symptoms of cranial osteo-myelitis continued for weeks. When the pericranium began to attach itself to the bone again the headache gradually subsided. The wound was nearly healed when he left the hospital, two months lacking six days after admission. I am also indebted to Prof. Gouley for the foregoing history of this case. I likewise think that potassium iodide in full doses was administered to this man for the cranial osteo-myelitis, and that it was beneficial.

Comments.—These two cases resemble each other very strongly. In both, the injury was caused by stones of similar weight falling from a great height, and striking upon the left parietal eminence, *i. e.*, upon the thickest, most arched, and strongest part of that bone. These peculiarities of the part of the bone that happened to be struck, account satisfactorily for the comparatively small amount of splintering which was sustained by the inner table in each instance. In both cases the operation of trephining averted the risk of meningo-cerebral inflammation which was feared. In both cases this operation was not followed by any troublesome symptoms,

excepting some that were quite accidental, and were due to inflammation of the medullary tissue of the injured part of the parietal bone, which was caused not so much by the operation itself as by the foul air of the hospital wherein the men were treated. This complication would not have occurred in private practice, nor under the antiseptic plan of after-treatment. Moreover, it did not prove fatal.

The bad effects of hospital air upon cases of trephining were noticed as far back as the time of Quesney. It is stated incidentally in one of the observations published by that eminent writer, that the operation of trephining "seldom succeeded at the hospital, on account of the unwholesome state of the air" (*op. cit.* p. 11). In the following instance the inner table was broken to a much greater extent than the outer, and the fragments thereof were found to be driven inward much further than the external fragment, with a blood clot interposed between them.

CASE XXIV. *Punctured Fracture of Right Parietal; Trephining: Recovery.*—John R., aged 41, on July 17, 1865, received four wounds of the head from stones thrown at him. On the following day he was admitted to hospital. He was perfectly sensible, but had marked contraction of the pupil with accelerated pulse and tremulous voice. There was considerable ecchymosis about the orbits. Three of the wounds proved to be mere scalp wounds. The fourth, however, was on the right parietal eminence; and, upon close examination, a minute depression of the bone, one-third of an inch in diameter, was discovered, evidently produced by a blow from the sharp edge or angle of a stone. His scalp was divided with cruciform incisions three inches long, having the original wound at their junction, the flaps reflected, the crown of a trephine applied, and a disk of bone, seven-eighths of an inch in diameter, removed, which was found to include, with remarkable exactness, a depressed fragment of the vitreous plate. Between the diploe and the depressed lamina there was a coagulum. The dura mater was uninjured. The wound of operation was drawn together with sutures, leaving an aperture, however, over the trephine-hole, into which a pledget of charpie was inserted. The patient was ordered to observe perfect quiet and strict diet. The case proceeded without an unfavourable symptom. On July 23d the sutures were removed. On 24th the pledget of charpie was taken away, and healthy granulations appeared beneath. The man recovered without a bad symptom, and was discharged from service September 8, 1865. (*Loc. cit.* p. 59.)

Comments.—In this case the piece broken off from the inner table was several times larger than the piece broken off from the outer table, since its principal diameter was seven-eighths of an inch while the corresponding diameter of the latter was only one-third of an inch. It was also depressed much more than the external fragment, and a clot of blood occupied the space between them. It pressed upon the dura mater in such a way as to produce symptoms of cerebral irritation, viz., marked contraction of the pupils, with accelerated pulse and tremulous voice. It pressed upon the dura mater in such a way that, in all probability, it would have excited fatal meningitis, but for its timely removal by operation. This case, then, serves to illustrate, in a very gratifying manner, the good that may be derived from trephining punctured fractures of the cranial vault, at an early period, and without waiting for the development of inflammatory symptoms. In the next example meningitis supervened, and the case progressed from bad to worse until trephining was performed.

CASE XXV. Punctured Fracture of Right Parietal from falling upon a Nail; Dura Mater pierced and Brain wounded; Convulsions and Profound Coma; Trephining; Recovery.—An infant, aged 12 months, became impaled on Sept. 20th, at 6 P. M., by falling headforemost upon a tennypenny nail, and considerable force was required to pluck the child away. At 7 o'clock, Dr. J. L. Van Ingen saw the case. The pulse was frequent, but there was no other important symptom. Upon exploring the wound it was found that the nail had pierced the skull upon the right parietal eminence, and penetrated the head to the depth of two and one-quarter inches. At midnight the child vomited, and had slight general convulsions, which lasted about half an hour. The rest of the night the child slept naturally.

Sept. 21st, at 9 A. M., was called in consequence of the return of unfavourable symptoms. About this time vomiting came on again, and convulsions on the left side, which continued until about 10 o'clock, when the muscles of that side became paralyzed, except those of the face, which continued to be convulsed until half-past 10 o'clock, when the child became insensible, and commenced sinking.

Dr. Van Ingen now advised trephining to remove the small fragment of bone displaced by the nail, on the ground that it produced unfavourable symptoms by acting as an irritant; but a consultation decided that the operation was unwarrantable, and held out no reasonable hope of benefit, *first*, because so small a piece of bone as the end of the nail displaced could not produce such grave symptoms; *secondly*, because the brain of a child could readily accommodate itself to much greater pressure; and, *thirdly*, because it was probable that the convulsions, coma, and sinking were not due to the irritation produced by the minute portion of displaced bone. Indeed, it was regarded as improbable that any displacement existed, for even if the inner table had yielded to the pressure of the nail, it was supposed that, from its great elasticity at so young an age, it had resumed its natural position. The symptoms were, therefore, attributed to the penetration of the nail into the substance of the brain to so great a depth.

The child continued to sink rapidly. At noon the skin was cold; there was no pulse at the wrist, and but little in the carotids. Dr. Van Ingen again urged the operation; and those before opposed to it now consented, on the ground that the child would certainly die, and that the operation, if it did not save it, would only shorten its life an hour or two. The patient was perfectly insensible, the breathing scarcely perceptible, and the incisions of the scalp were apparently unfelt. When the bone was fully exposed a small irregular aperture therein was discovered, sufficient to admit the passage of the nail, the sides of which gradually approximated each other at the bottom, the nail having entered obliquely. Upon removing the depressed portion of bone with the trephine, the child became sensible, the muscles on the left side of the face commenced twitching, then those on the whole left side of the body, and, immediately after, those on both sides of the whole body were affected with a slight convulsive movement; the pulse returned at the wrist, the heat to the skin, and the child recovered the free use of its limbs except the left arm which remained partially paralyzed.

The wound was then dressed, the patient was removed to a dark and quiet room, to secure the brain against irritation from light and noise. At midnight the child had a slight convulsion—gave morphia sulph. gr. $\frac{1}{8}$ —and the remainder of the night it slept soundly.

22d. The day after the operation the use of the arm was perfect.

28th. The patient was removed to the family room, and the wound healed entirely in about three weeks. No further medication was used after the morphia on the first night after the operation, with the exception of one drachm of castor-oil and the application of rum and water to the head.

April, 1854. The child is healthy; has never had fits, spasms, or spasmodic actions of the muscles since his recovery from the operation in September, 1847. (*New York Journal of Medicine*, May, 1854, pp. 378-381.)

Comments.—By the operation of trephining this little patient was saved from certain death. On this point there is no room for doubt; besides, the performance of the operation ought not to have been obstructed

by the consultation, for every moment of delay rapidly diminished the chances of recovery ; as it was, the little patient had a very narrow escape, although the performance of the operation was delayed for only an hour and a half, or two hours at most. This case, then, serves well to show not only the great value of trephining as a remedial measure in cases of punctured fracture of the cranium, but likewise the great danger which may result from deferring its performance.

The extreme youth of this patient reminds one of something which possesses practical importance, viz., depressions of the skull of infants can sometimes be removed by putting on cupping-glasses. On this point Prof. Eve says : " I have heard of no less than three cases of depressed skulls in young children relieved by exhausting the air from a cupping-glass placed over the portion of the cranium driven below the surrounding level. One instance occurred in Europe, the second is recorded by Dr. Moultrie, of St. Johns, S. C., and the third was mentioned to me by my colleague, Prof. Briggs." (*Remarkable Cases in Surgery*, p. 48.)

When operating for depressed fractures in general, the main object is to elevate or remove the sunken pieces of bone. Now, if this can be accomplished with the elevator alone, so much the better. Should this not be feasible, then we must try to obtain sufficient room for the elevator by removing a slice of the sound bone overhanging the depressed fragment ; and this is to be done by Hey's saw, if possible. The trephine should be resorted to only when its employment is indispensable ; and in trephining for depressed fracture, care should be taken to remove as little bone as possible ; but, in our anxiety not to remove too much bone, we must be especially careful and make ourselves perfectly sure that no irregular margin of the inner table is left behind pressing upon the meninges. In looking over the skulls in our different museums, it is curious and most instructive to observe how frequently a sharp edge of the inner table has been left depressed. (*Prescott Hewett*.)

The following rather remarkable instance of penetrating wound of the head, involving the scalp, the skull, the meninges, and the brain itself, is here related, because of the resemblance which this injury is supposed to bear to punctured fracture of the cranium :—

CASE XXVI. Jacob F., æt. 23, was admitted to Bellevue Hospital Sept. 4, 1867. On the night of admission the patient was struck on the head with a pocket-knife. The blade entered the skull one inch in front of the left ear and one inch above the zygomatic arch, and penetrated its entire length, two and one-half inches. On admission he complained of a sense of numbness in the head, dimness of vision in the left eye, and partial deafness in left ear. Much effort was required to remove the knife, so closely was it pinched by the bone. A pair of bone forceps were applied to the handle, and while two men held the patient's head, the house surgeon and his assistant made strong traction by means of the forceps. The knife finally came away ; considerable hemorrhage followed ; the temporal artery was severed. The patient was ordered to remain quiet

in bed, and a compress was applied over the wound. No bad symptoms were developed, and the patient was discharged, at his own request, five days after the receipt of the injury. Partial deafness of left ear and partial paralysis of left side of face, but no dimness of vision remained. I have not been able to learn what happened in the end to this patient, but he did not return to the hospital, and his case was not the subject of coroner's inquest, at least so far as I could find, which circumstances tend to show that he recovered, although they by no means make it certain.

In the next case the cranial vault received a fracture from a spent ball, very like in appearance to many of the fractures which are produced by the rounded corners of stones when falling from some considerable height or when hurled with some considerable force against the head (*e. g.*, Cases XXIV., XXIII., XXII.), and which are usually termed punctured fractures. The depressed splinters of the inner table were neither elevated nor removed, as no operation was performed, and thus remaining in contact with the dura mater, they kindled an inflammation in the meninges which proved fatal. This case of punctured fracture of the skull from gunshot will serve well to show the course and termination of punctured fractures of the skull in general, unless the broken pieces of the inner table are removed by operation. The writer watched the progress of this case with deep interest.

CASE XXVII. G. W. Bricker, 10th Pa. Reserves, aged about 25, received at the battle of Fredericksburg, Va., on Dec. 13, 1862, and was admitted to Stanton Hospital therefor on Dec. 14th, a scalp-wound on the left parietal bone near its anterior border about one inch in length, which was inflicted by a canister shot, and extended down to the skull. No depression was detected. The injury was judged to be slight, and the patient appeared to progress favourably till nine days after the injury, and eight days after admission to hospital. On this day he complained of intense pain in the left or injured side of his head; was feverish, restless, and complained of being disturbed by noise; pulse accelerated and skin hotter than natural; pupils natural, and he protruded his tongue well. He now said he had had some headache ever since admission.

On the 23d at 10 o'clock P. M., he had a chill, and another at 3 o'clock A. M., on the 24th. At the morning visit this day he was somewhat delirious; pupils natural; some insensibility of right side of body was also noticed. A blister was applied to nape of neck, and free catharsis induced. In the afternoon of 24th he had recovered his senses to all appearance, and had certainly recovered the sensibility in his right inferior extremity which he seemed to have lost in the morning.

25th. The case is thought to be complicated with malarial fever, and quinia in full doses was ordered as an anti-periodic. The patient was still able to walk.

27th. Has ceased to have chills and fever.

30th. Much worse, and lies semi-comatose; pulse slow and feeble; bowels open; no chill since 25th. A small swelling of the scalp was noticed just anterior to the wound, which, on being opened, was found to contain some dark-coloured blood. From this time the patient gradually grew worse till January 4th, when he died comatose: no convulsions having occurred at any time in the progress of his case.

Autopsy.—The external table of the left parietal bone is seen to be indented by a bullet with a circular depression half an inch in diameter just behind the coronal suture. On removing the calvaria the inner table is seen to be irregularly fissured and depressed half a line. About an ounce and a half of bloody pus had collected between the dura mater and the cranium at the place of fracture. A layer of pus had also been formed on the inner surface of the dura mater in the arachnoid cavity in same situation. The brain itself presented no morbid appearance. There was no lesion of Peyer's patches. Other organs healthy. On examining the osteological specimen after it was thoroughly cleaned, it was quite remarkable to observe that several of the fragments of the inner table were firmly reunited, although the patient had survived his injuries only twenty-two days.

Comments.—The inner table, in this case, was broken more extensively than the outer table, and the sharp splinters of it were depressed enough to prick and irritate the dura mater, thereby producing inflammation of that membrane. The first step in the treatment of this patient, therefore, should have been the fulfilment of the causal indication, *i. e.*, the timely removal of the offending splinters of the inner table, which could easily have been accomplished by the operation of trephining. The fatal issue of the case and the morbid conditions disclosed by the autopsy show that, without trephining, this man's recovery was impossible. Why, then, was this operation not performed? It happened, firstly, because the existence of a cranial fracture was unknown. Careful examinations of the scalp-wound repeatedly made by myself and others had failed to detect any lesion of the skull. The indentation of the external table was so slight that it escaped observation. Secondly, malarial fever supervened, and the symptoms which it produced masked the symptoms of traumatic meningitis, and caused us to mistake the stupor of a cerebral compression resulting from the products of meningeal inflammation for the stupor of typhomalarial fever. Moreover, he improved very much in every way under liberal doses of quinia, and this circumstance tended to lead us still further astray in our views of his case, until the results of the autopsy set us right, by showing us that there was punctiform fracture of the skull with slight depression and circumscribed inflammation of the dura mater with a large collection of purulent matter between that membrane and the broken part of the skull. The case was, therefore, a very favourable one for successful operation with the trephine, if the differential diagnosis could only have been made in season; and I have deeply regretted ever since that I did not follow the promptings of a sort of surgical instinct which strongly inclined me to operate as a remedial measure of last resort, instead of obeying the dictates of a too cautious conservatism.

The history of this case, then, presents in a strong light the disastrous consequences which commonly ensue, when, from any cause, the rule of surgery which requires depressed fractures of the skull with external wound, but especially the punctured forms thereof, to be remedied by operative

procedures at an early day, is not strictly followed out in practice. Moreover, it is the solemn lesson taught by this case which more than aught else has impelled the writer to discuss with so much earnestness and copiousness the question of trephining in fractures of the cranial vault.

ARTICLE IX.

FATAL INTESTINAL OBSTRUCTION BY GALL-STONES. By FRANK WOODBURY, M.D., Physician to the German Hospital, Philadelphia.

CONTRARY to the general observation that, in cases of biliary colic, the attack is terminated when the gall-stone is discharged into the intestinal canal, it will exceptionally happen that the concretion causes further pain and annoyance in its passage down the small intestine; or, it may even be so large as to block up the tube, and, becoming impacted, cause fatal obstruction of the bowels.

The causation of gall-stones is still unsettled, and their law of development little understood, although Murchison¹ notes the frequent coexistence of the uric acid diathesis, and Dr. George Budd believed that their development might be connected with the drinking of porter, which, it is well known, also favors the occurrence of gout. Like the gouty diathesis the tendency to gall-stones may be hereditary. Whatever, may be their pathological source, or their predisposing cause, it is evident that their formation is greatly favoured by the complex constitution of the bile, in which fatty and resinous substances, lime-salts, and cholesterine are held in a state of unstable solution in the mucus principally by the aid of sodium chloride, phosphate, and carbonate, and the sodium salts of the biliary acids. Should a change of composition occur, and to this no secretion in the body is more subject, some of these insoluble substances may be deposited either in the bile passages or in the gall-bladder itself. In the former situation the sabulous material is probably, as the rule, discharged into the intestine and lost; in the latter position its escape is opposed by the peculiar spiral and crescentic folding of the mucous membrane lining the cystic duct, and it is, therefore, frequently retained to act as a nucleus upon which the crystallization of cholesterine may take place, or other constituents of the bile deposited.

The prevalence of gall-stones excites surprise that they do not give trouble oftener than they actually do. It is by no means an uncommon event in the post-mortem room to discover concretions, even of large size, that gave no symptoms whatever during life, and whose existence even was entirely unsuspected. It is also a matter of common observation that the

¹ Functional Diseases of the Liver, London, 1874.